UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Survey of helium in natural water wells and springs in southwest Montana and vicinity and Imperial Valley, California

Part IV - Jan. 1 - Dec. 31, 1981

by

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Open-File Report 82-486

1982

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This report covers a continuing project to study the relationship between changes in helium in natural water wells and springs and the occurrence of earthquakes. Bulashevich and Bashorin have (1974) discovered helium changes just before an earthquake, so this helium monitoring method might be successfully employed to predict earthquakes. Previous work on this project has been reported by Doering and others (Doering and Friedman, 1980a, 1980b; Doering and others, 1981).

During 1981 collectors sent water samples to our Denver laboratory from fifteen wells or springs located in and to the northwest of Yellowstone National Park. Water samples were received from six wells in the Imperial Valley of southern California. A brief description of these helium sampling stations is given in Table 1 and their locations are shown on the maps of Figures 1 and 2. We received samples from a few stations for only part of the year.

The samples are collected by withdrawing about nine milliliters of water into a plastic syringe and immediately injecting it into a Vacutainer glass tube that is evacuated to one-fifth atmosphere by the manufacturer. Usually one sample is collected each day. When five samples have been collected they are mailed to the laboratory of the U.S. Geological Survey located at the Denver Federal Center.

The water samples are analyzed on a helium leak detector mass spectrometer. The analytical precision is ± 5%. However the overall

precision of the collection and analysis is ± 20 %. The method of analysis is described in Doering and others, 1981. The data are shown in Figures 3 through 23. Figure 24 makes it possible to convert Julian dates on the graphs to the commonly used calendar dates.

During 1981 the National Earthquake Information Service reported that three earthquakes having a magnitude of 3.0 or greater occurred in Southwest Montana and vicinity, and 41 earthquakes occurred in the Imperial Valley (U.S. Geological Survey, 1981). Table 2 lists the five earthquakes having a magnitude greater than 4.0. It also shows the dates of occurrence, epicenters, and magnitude of these quakes. The most intense one, magnitude 5.6, came on April 26 (Julian day 116) and was located at Westmorland which is about 6 miles northwest of Brawley, Calif. There were 11 foreshocks on April 25 and 26 as well as 17 aftershocks on April 26 and 27. The Julian dates of the five largest earthquakes are indicated by tick marks on the graphs of Figures 3 through 23.

There are some anomalies shown on the graphs that are difficult to explain and have no obvious relation to earthquakes. There was an abrupt increase in helium during the period of days 274 through 289 at stations 301, 308, 310, 318, 319 and 321. There was a sharp decrease in helium after day 152 (June 1) at station 316 and a reduction in the daily variation as well. There was a large increase beginning on day 137 (May 17) in station 318. This anomaly may be explained by the fact that a better location at which the spring emerges from underground was found at Thexton Hot Spring from which to collect the water sample. This place taps the underground spring before the helium can escape into the air.

A few stations appear to show a change in helium about the time of a reported earthquake. There was a decrease in helium at stations 301 and 308

located at West Yellowstone, Mont. three weeks prior to the earthquake on day 142 (May 22). The epicenter was located near this city. In California, there was a small but abrupt helium decrease at station 344 right after the earthquakes on days 115, 116 and 205. There was a helium decrease after the earthquakes on days 115 and 116 and before the quake on day 205 at station 349.

This earthquake prediction project is being continued to gather more data and monitor the relationship between helium changes and earthquakes. We wish to thank the sample collectors for their cooperation in making this study possible.

Table 1.--Localities of helium-sampling stations

Station No.	Station Name	Address	Comments
300	Miller	Dick Miller River Route, Box 490 Gardiner, MT 69030	58.5 m (192 ft) deep well; pump at 50.3 m (165 ft); pumped continuously at 7.6 lpm (2 gmp); water temp. 67°C, (153° F). This well is about 300 m (984 ft) from a small warm spring, and 1000 m (3281 ft) from La Duke Hot Springs, a large hot spring. The water is high in fluorine and iron.
301	Beer	Paul Hantelman U.S.G.S. Box 1049 West Yellowstone, MT 59758	61 m (200 ft) deep well; water source for service facility at Yellowstone National Park.
307	Hunter's	Harold Johnson Box 132 Springdale, MT 59082	Hunter's Hot Springs.
308	Lapp	Allen L. Lapp Box 503 West Yellowstone, MT 59758	Town well, 67.7 m (222 ft) deep; cased to 45.7 m (150 ft).
310	Chico	Mrs. Jean Weeter and Mrs. Rosemary Bernethy Pray, MT 59065	Hot Spring.
311	Ralston	Mrs. Claudette Ralston Route 1 Emigrant, MT 59027	45.7 m (150 ft) deep well; fully cased; 45.5-56.8 lpm (12-15 gpm); water temp. is 10°C (50°F).
312	Bathtub	Paul Miller River Route, Box 490 Gardiner, MT 59030	Large warm pool at top of Mammoth Hot Springs, Yellowstone National Park.
313	Orr	Wesley Orr Ennis National Fish Hatchery, Ennis, MT 59729	Flowing Spring; 1515 lpm 400 gpm); water temp. is 12°C (54°F).

Table 1.--Localities of helium-sampling stations (Cont'd)

Station No.	Station Name	Address	Comments
314	Bozeman	E. M. Drake 133 Lower Rainbow Rd. Bozeman, MT 59715	Well that taps Bozeman Hot Spring, 167.6 m (550 ft) deep, having a flow of 2841 lpm (750 gpm); water temp. is 53.9°C (129°F).
316	Blakeley	Shirley Blakeley Route 38 Box 2249 Livingston, MT 59047	119 m (390 ft) fully cased well.
317	MacMillan	Richard MacMillan P. O. Box 761 Ennis, MT 59729	Domestic well, 42.7 m (140 ft) deep; 113.8 lpm (30 gm) flow; water contains H_2S; temp. is 53.3°C (128°F).
318	Thexton	Alex Yenny P. O. Box 748 Ennis, MT 59729	Thexton Hot Springs; water temp. is 84°C (184°F).
319	Stands	Mrs. Alvin Stands Pray, MT 59065	68 m (223 ft) deep well; cased for 30.5 m (100 ft).
321	Murphy	Jim Murphy Ox Yoke Ranch Emigrant, MT 59027	79.2 m (260 ft) deep well; perforated from 45.7-68.6 m (150-225 ft).
322	Kamps	George Kamps Route 38 P. O. Box 2071 Livingston, MT 59047	33.5 m (110 ft) fully cased well.
343	Blevins	Roy Blevins 5605 Butters Road Brawley, CA 92227	Old well of unknown depth, dug 50 years ago; temp. about 60°C (140°F).
344	Bowles	Mrs. Charles Bowles Box 74 Calipatria, CA 92233	356 m (1167 ft) deep artesian well; cased to 305 m (1000 ft); 663 lpm (175 gpm); temp. is 46.3°C (106°F).
345	Hagen	Julia Hagen 2190 East Titsworth Rd Brawley, CA 92227	About 305 m (1000 ft) deep well; temp. is about 38°C (100°F).

Table 1.--Localities of helium-sampling stations (Cont'd)

Station No.	Station Name	Address	Comments
347	Jeska	Johanna Jeska Holt Ave. Store 5449 Butters Road Brawley, CA 92227	Old well of unknown depth; drilled in 1930's; fully cased.
348	White	Mrs. Dorothy White P. O. Box 184 Ocotillo, CA 92259	88.4 m (290 ft) deep well.
349	Rodia	Jim Rodia P. O. Box 86 Ocotillo, CA 92259	183 m (600 ft) deep well; temp. is 33°C (92°F).

Table 2.--Earthquakes in reporting areas in 1981

Julian date	Calendar date	Latitude N.	Longitude W.	Region	Magnitude
115	April 25	33.12°	115.63°	Westmorland, CA	4.1
116	April 26	33.13°	115.65°	Westmorland, CA	5.6
116	April 26	33.10°	115.67°	Westmorland, CA	4.2
142	May 22	44.83°	111.0°	West Yellowstone, MT	4.2
205	July 24	31.78°	116.33°	S.W. of Ocotillo, CA	4.6

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Doering, W. P. and Friedman, I., 1980a, Survey of helium in natural water wells and springs in southwest Montana and vicinity: U.S. Geological Survey Open-File Report 80-181, 42 p.

Doering, W. P. and Friedman, I., 1980b, Survey of helium in natural water wells and springs in southwest Montana and vicinity, Part II-July 1-Dec. 31, 1979: U.S. Geological survey Open-File Report 80-1257, 18 p.

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U.S. Geological Survey, 1981, Preliminary determination of epicenters, monthly listing, April, May, and July, three publications: U.S. Geological Survey National Earthquake Information Service, 16 p., 12 p. and 12 p.

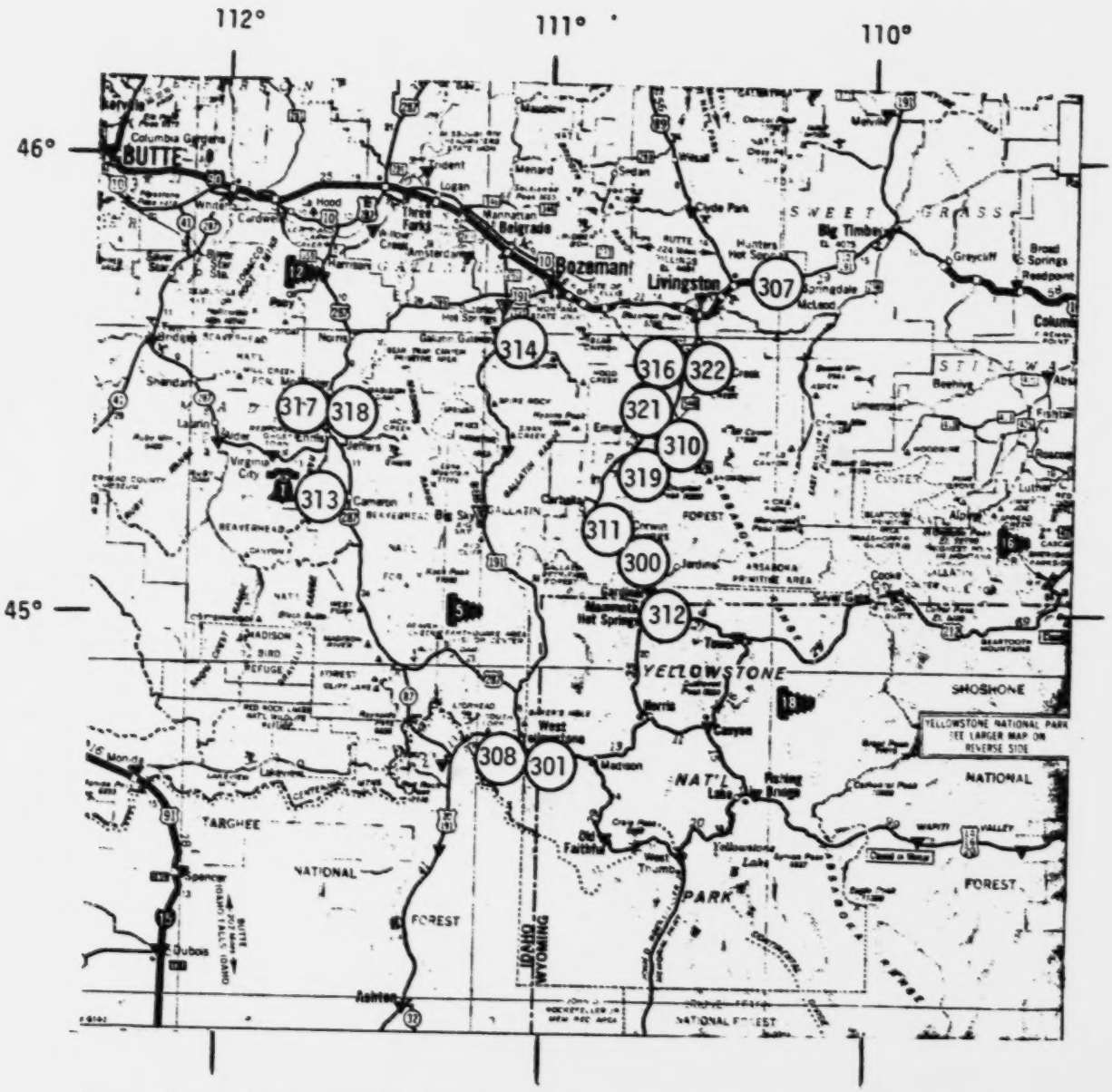

Figure 1.--Helium sampling stations (shown by number) in Montana and vicinity. Scale approximately 1:1,550,000 (1 inch to 24.6 miles).

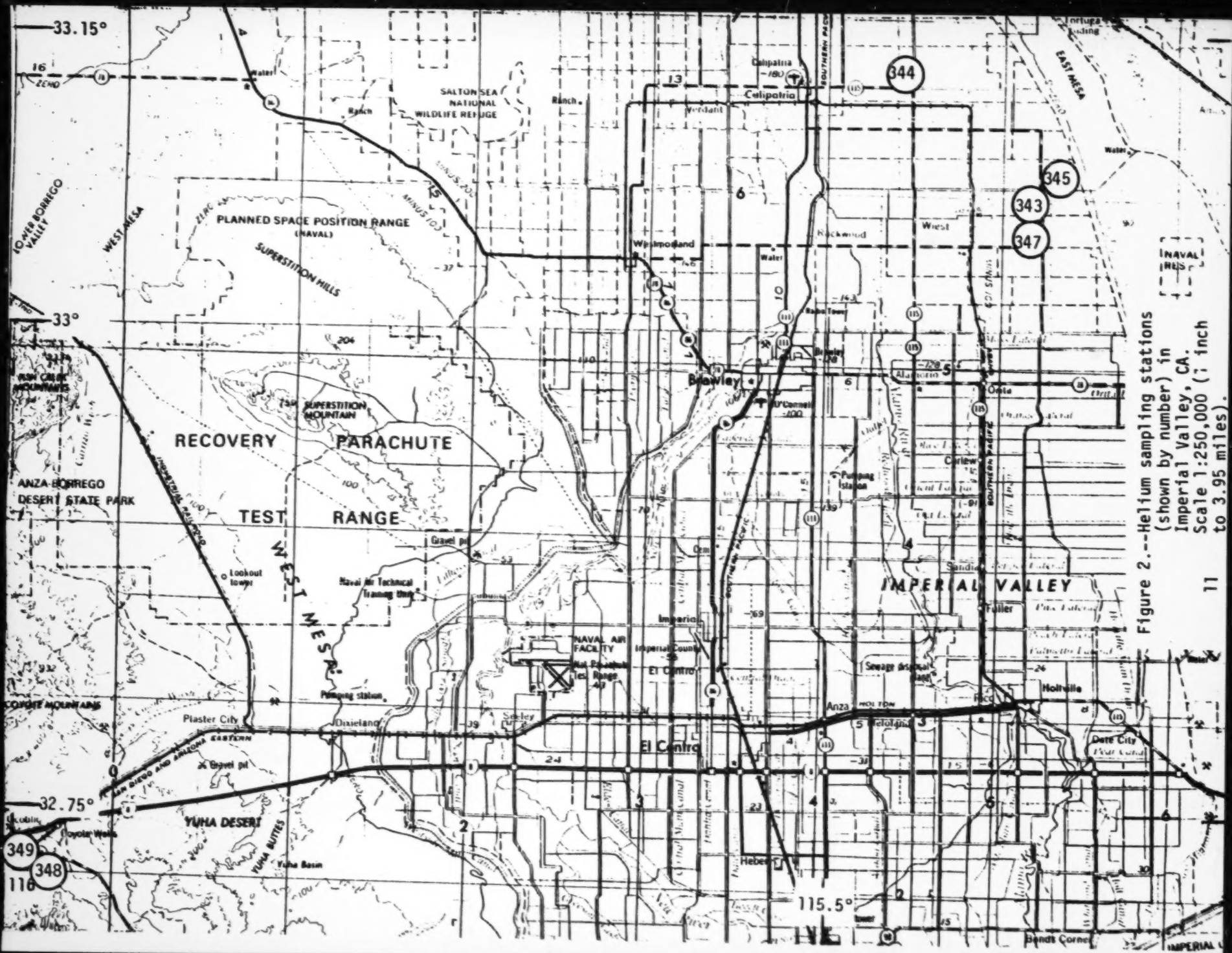

Figure 2.--Helium sampling stations (shown by number) in Imperial Valley, CA. Scale 1:250,000 (1 inch to 3.95 miles).

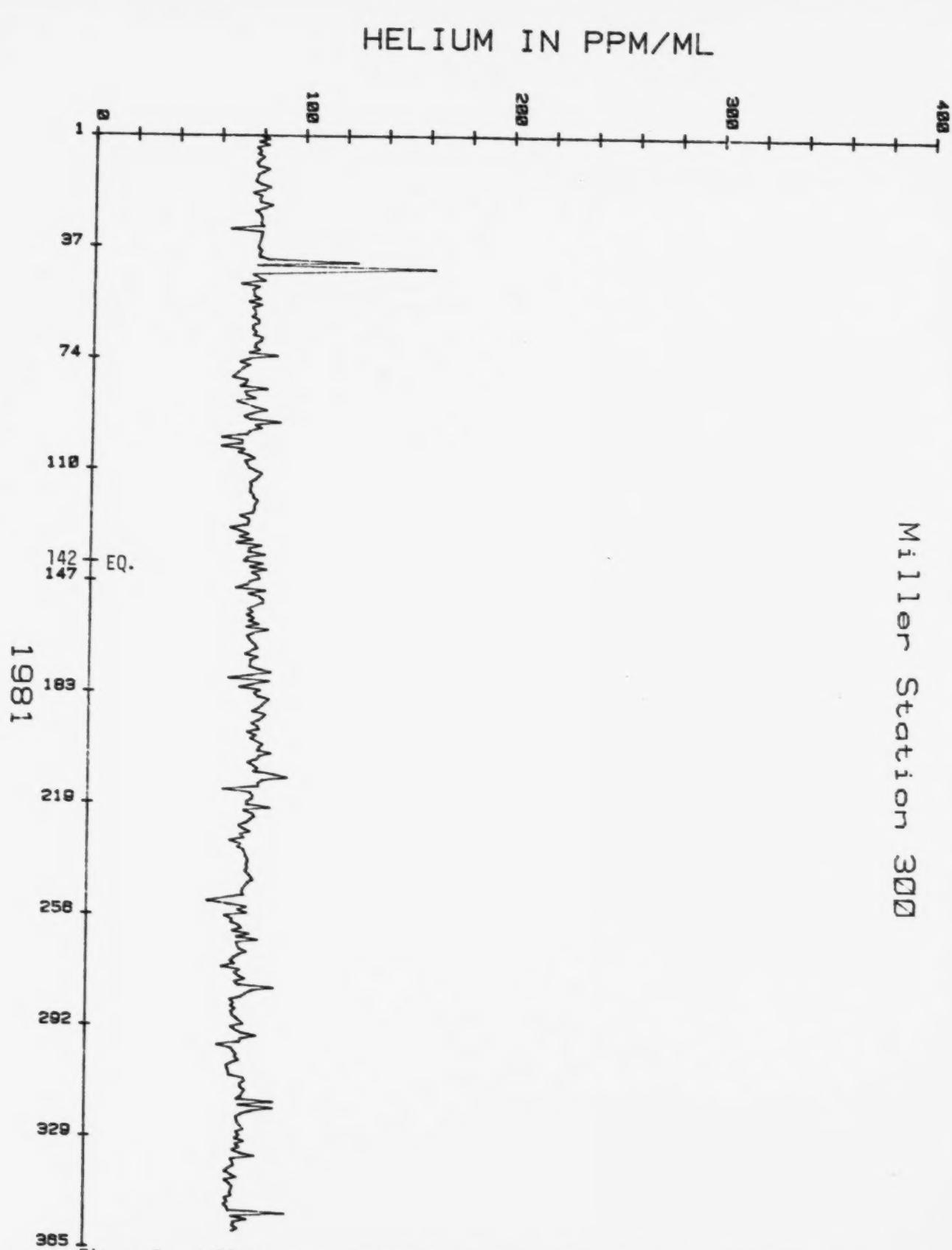

Figure 3.--Helium concentrations in water samples, Gardiner, Montana.

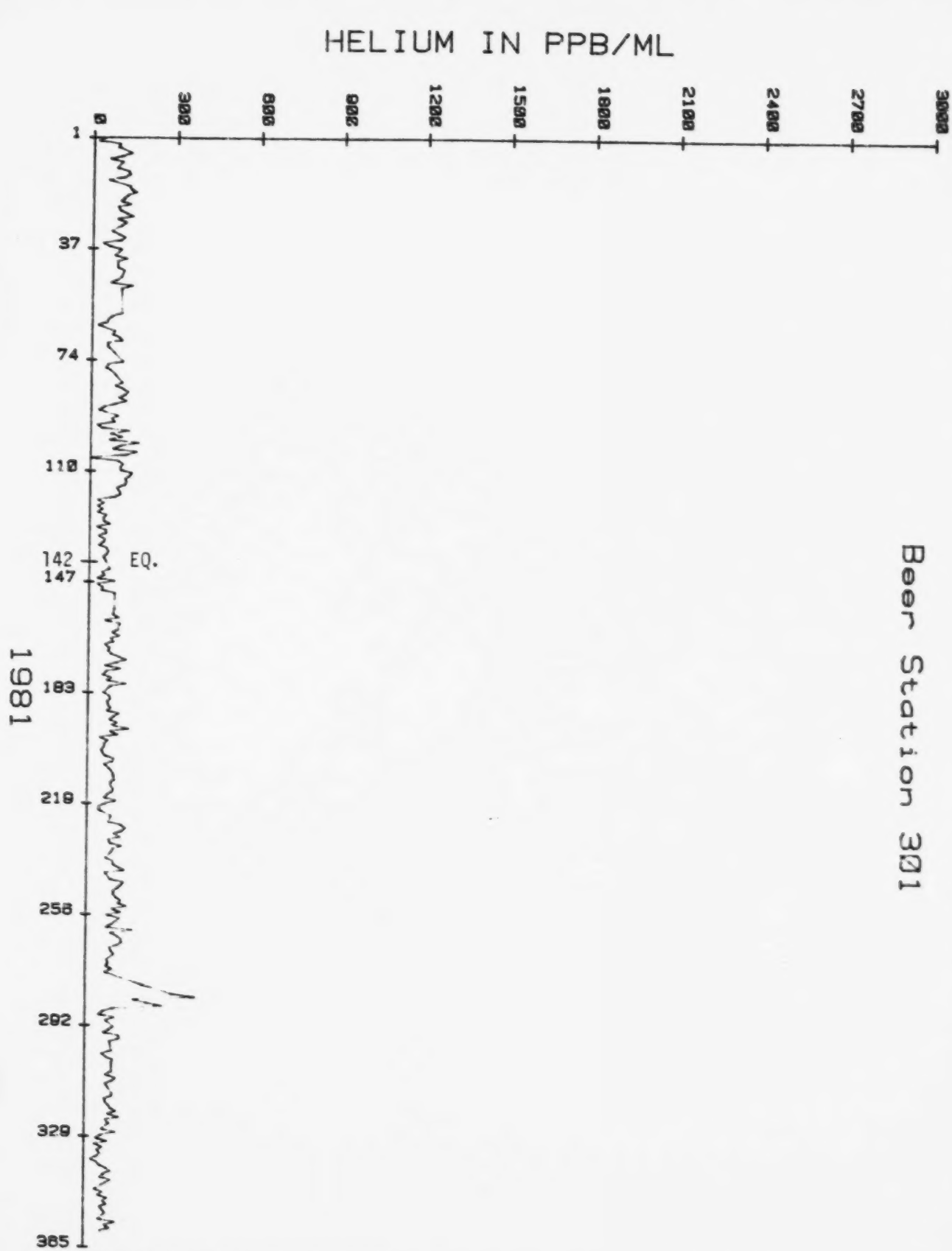

Figure 4.--Helium concentrations in water samples, West Yellowstone, Montana.

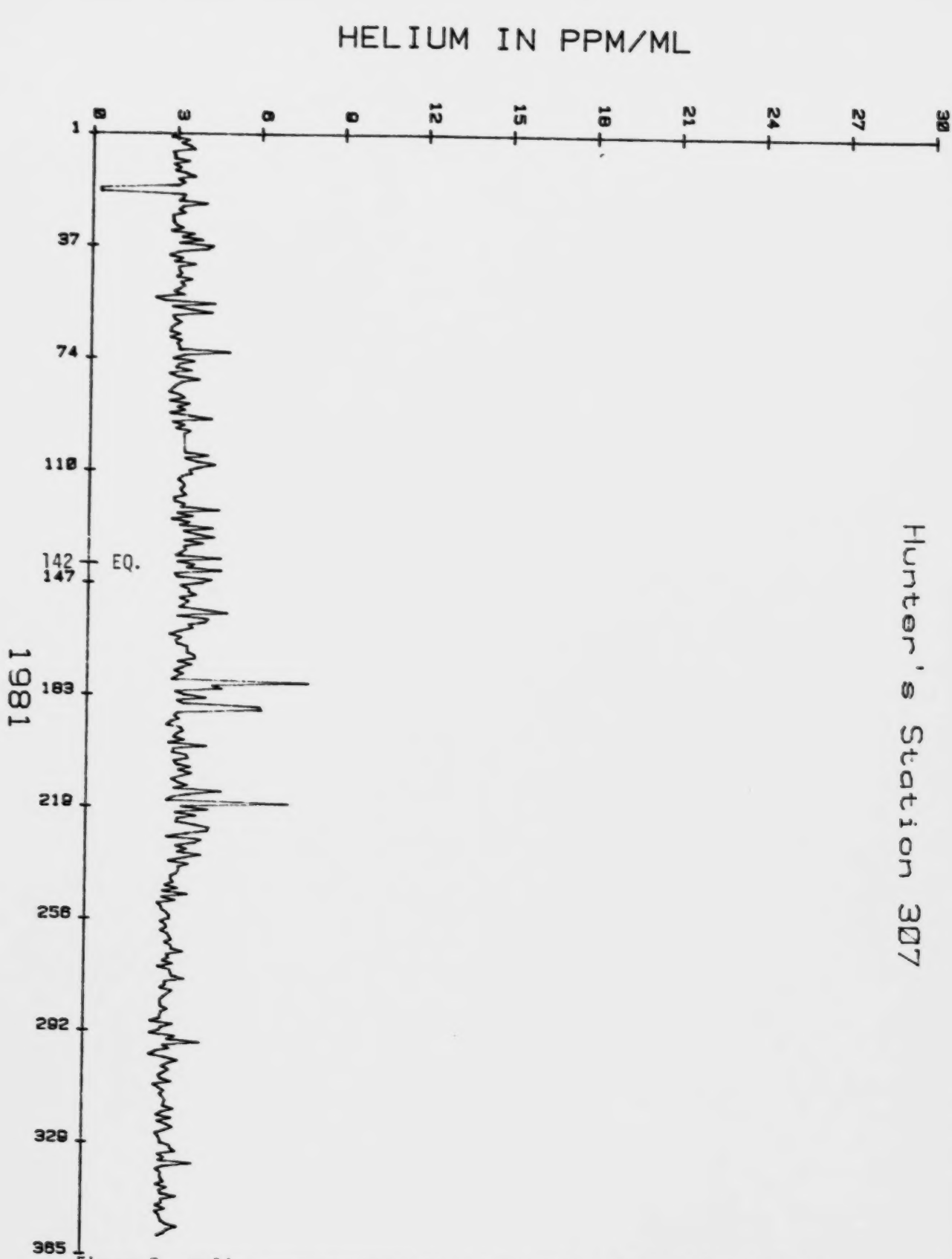

Figure 5.--Helium concentrations in water samples, Springdale, Montana.

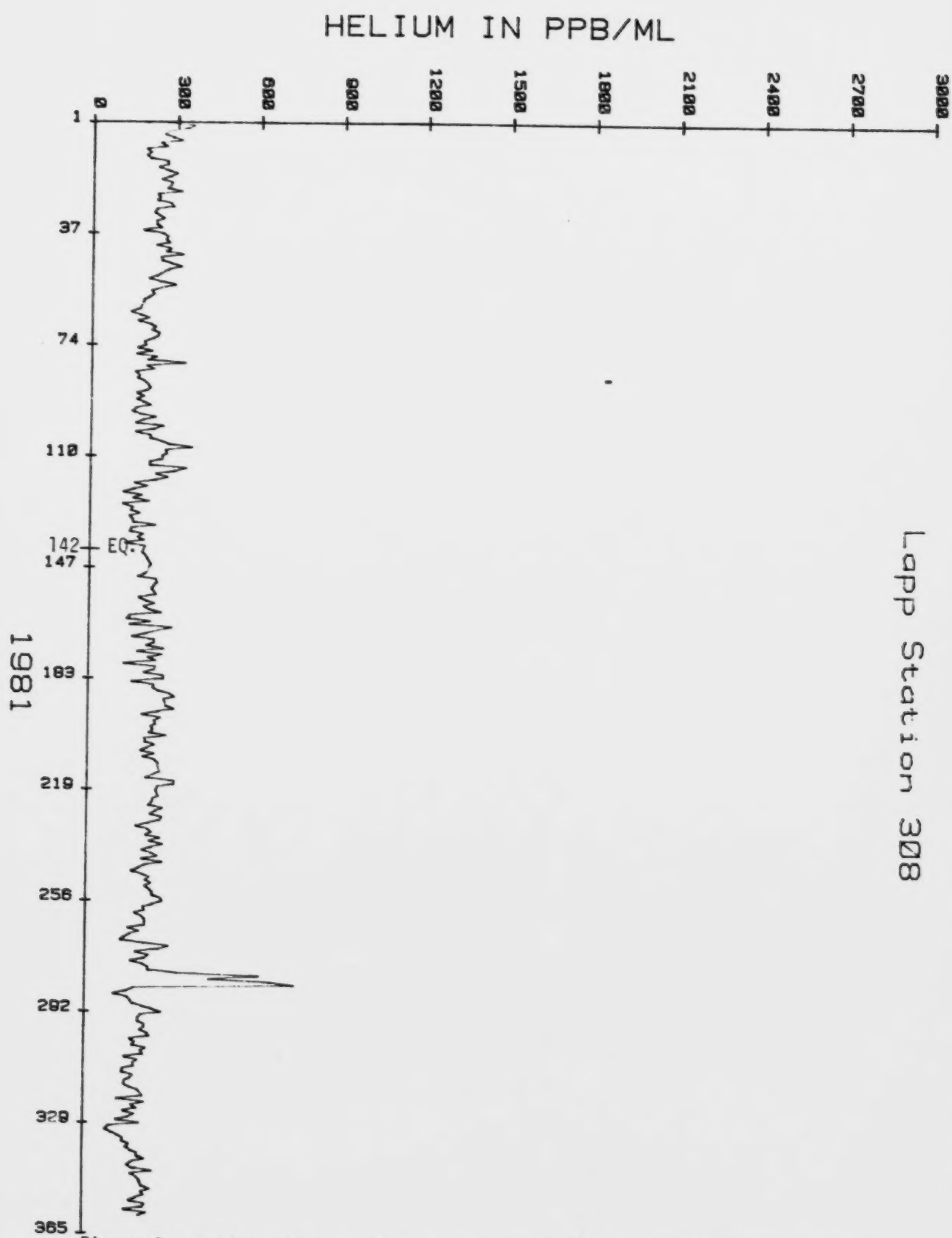

Figure 6.--Helium concentrations in water samples, West Yellowstone, Montana.

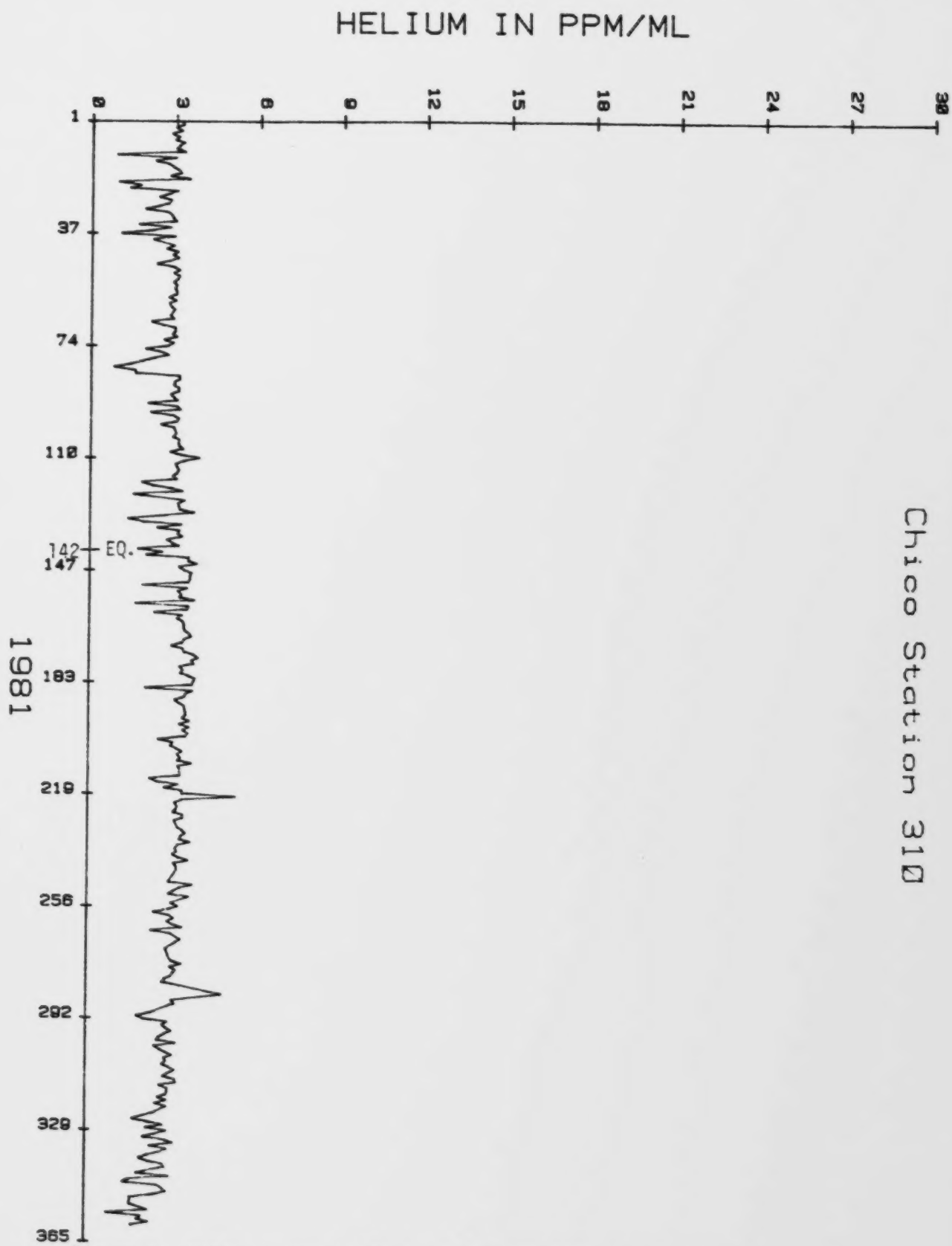

Figure 7.--Helium concentrations in water samples, Pray, Montana

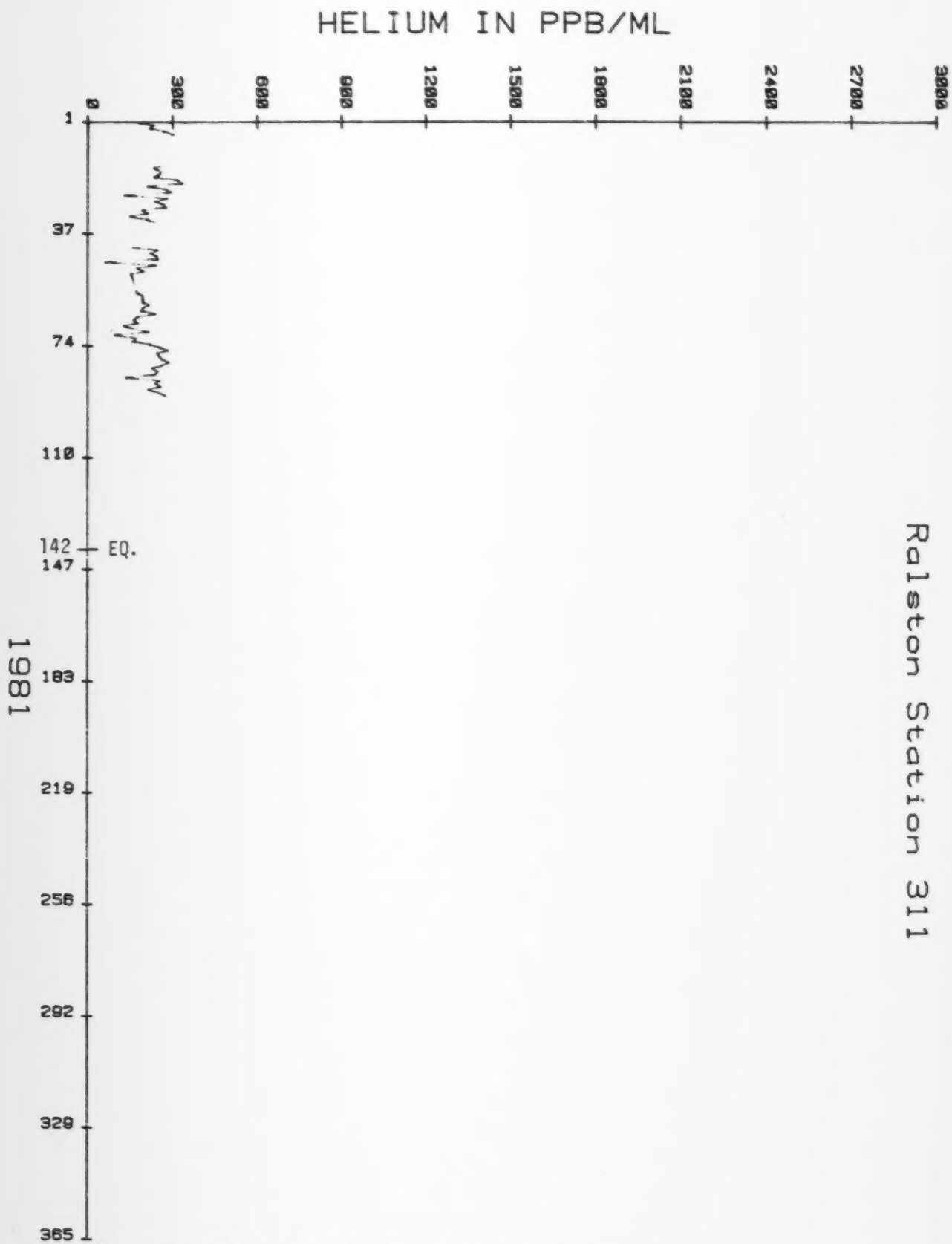

Figure 8.--Helium concentrations in water samples, Emigrant, Montana.

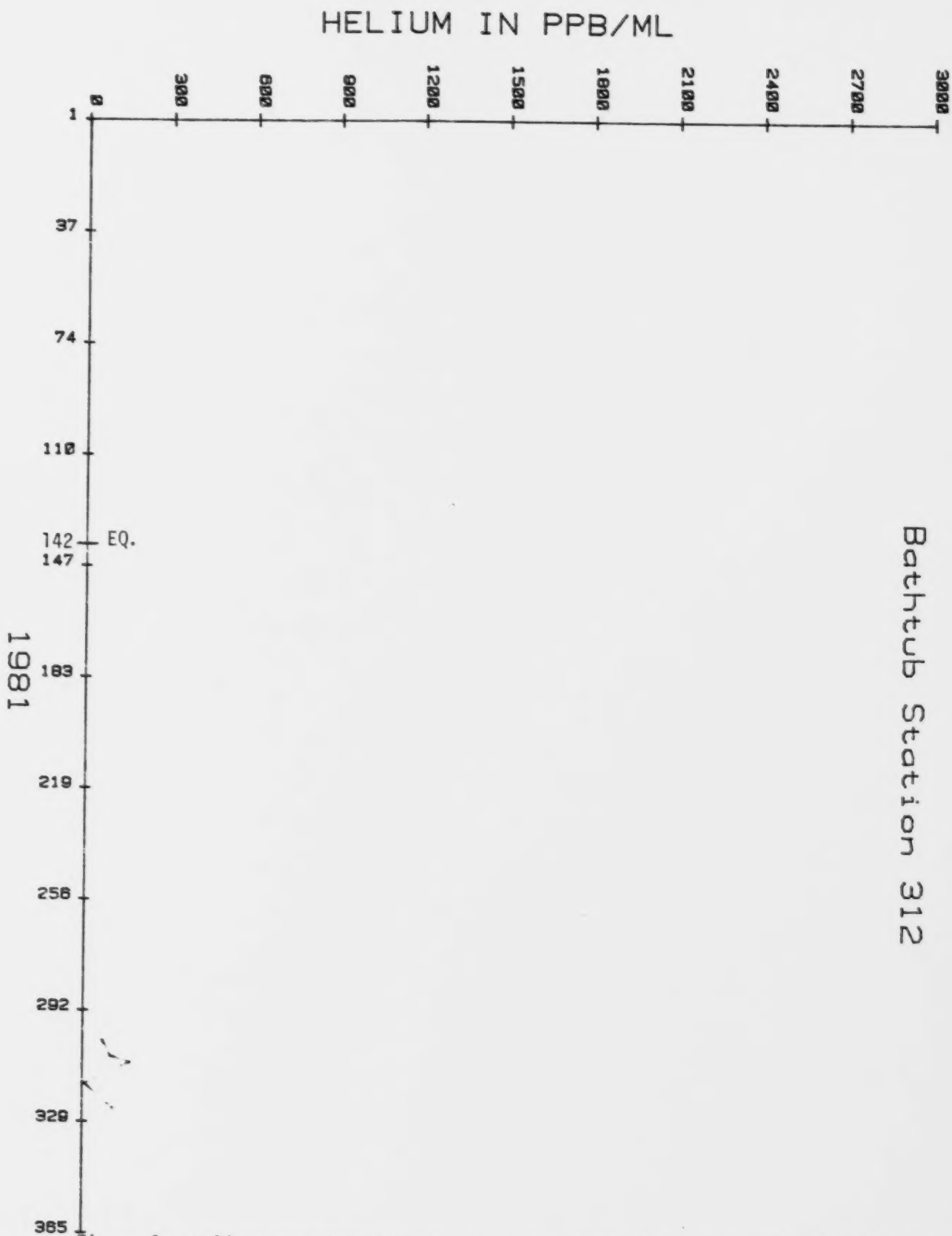

Figure 9.--Helium concentrations in water samples, Yellowstone National Park, WY.

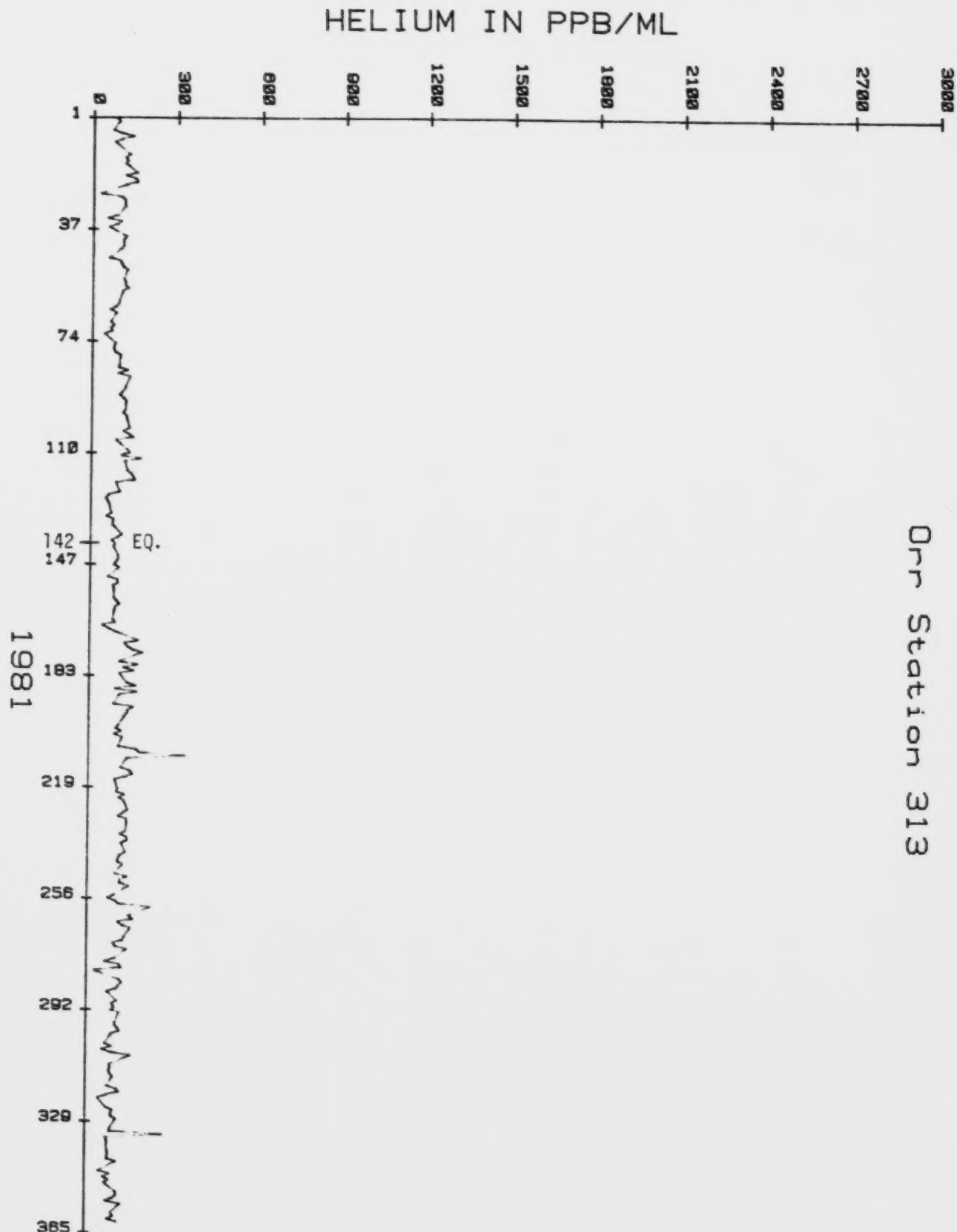

Figure 10.--Helium concentrations in water samples, Ennis, Montana.

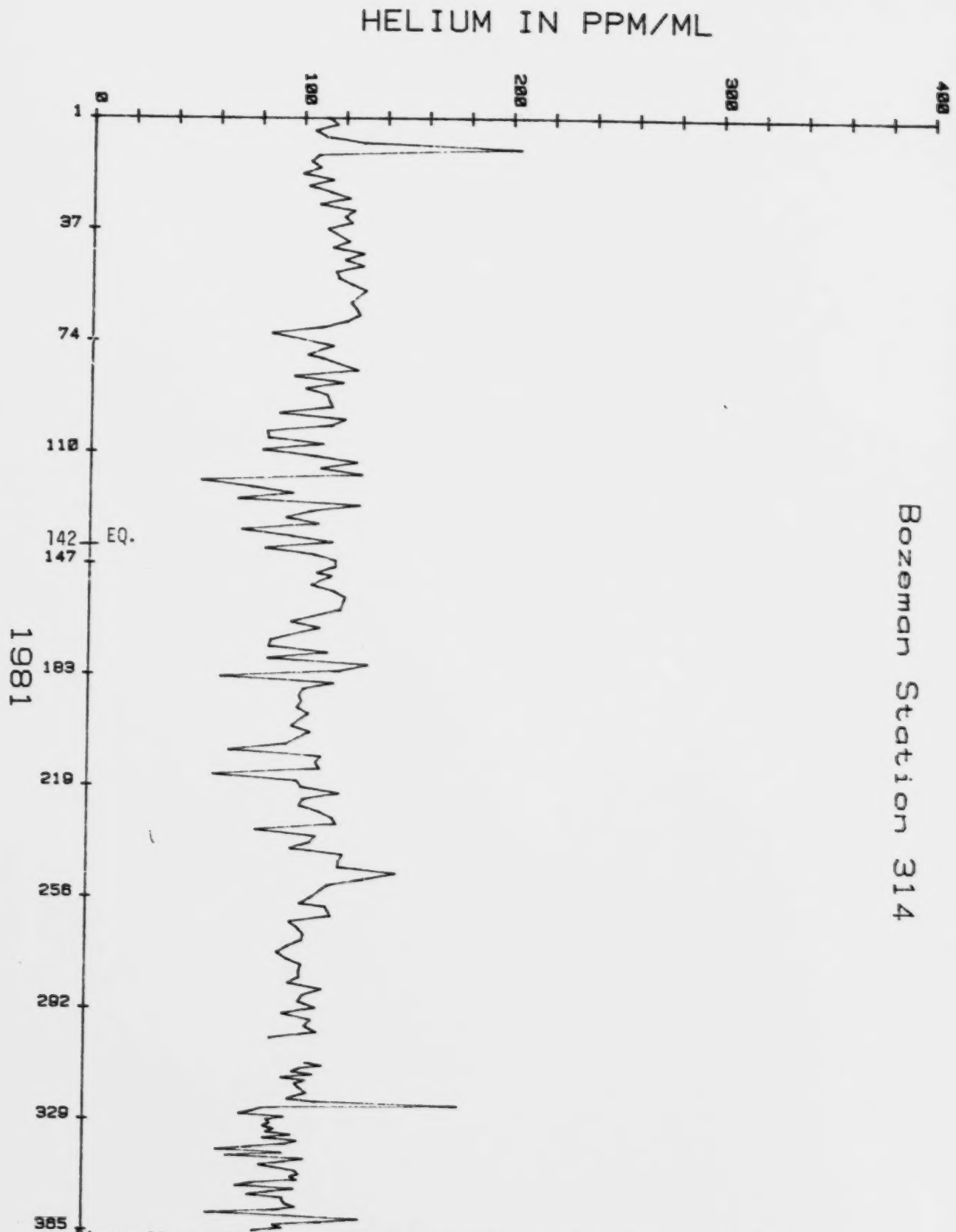

Figure 11.--Helium concentrations in water samples, Bozeman, Montana.

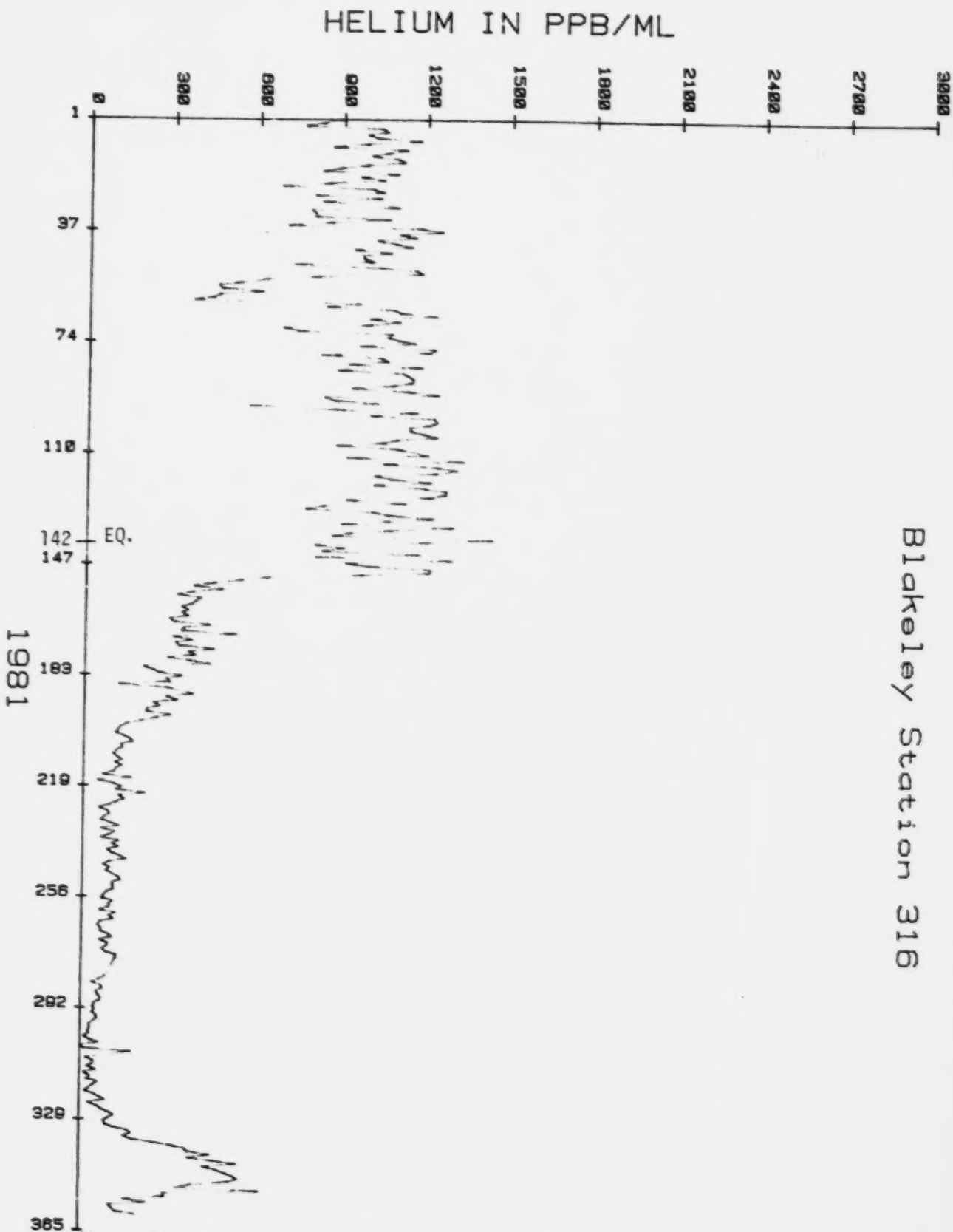

Figure 12.--Helium concentrations in water samples, Livingston, Montana.

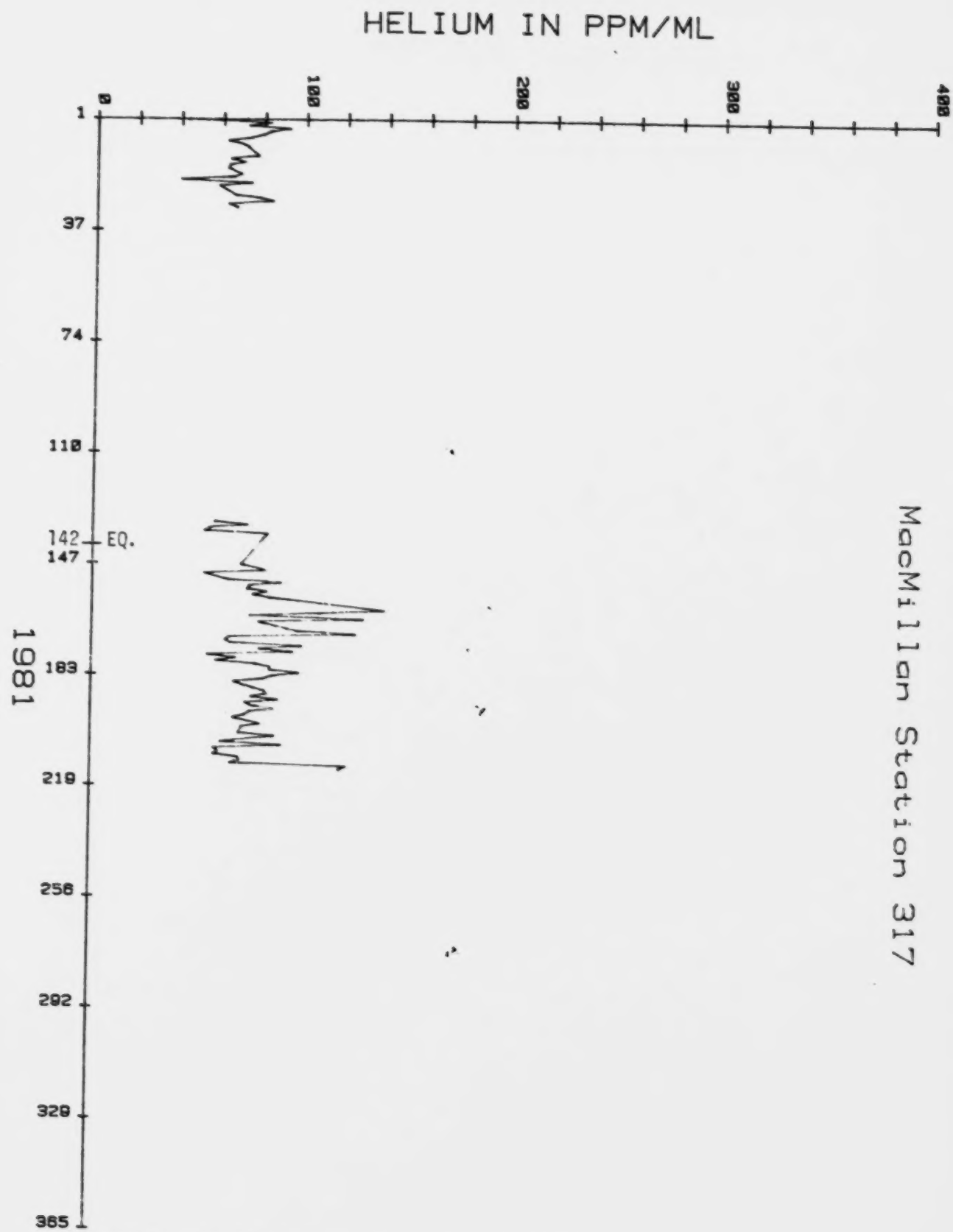

Figure 13.--Helium concentrations in water samples, Ennis, Montana.

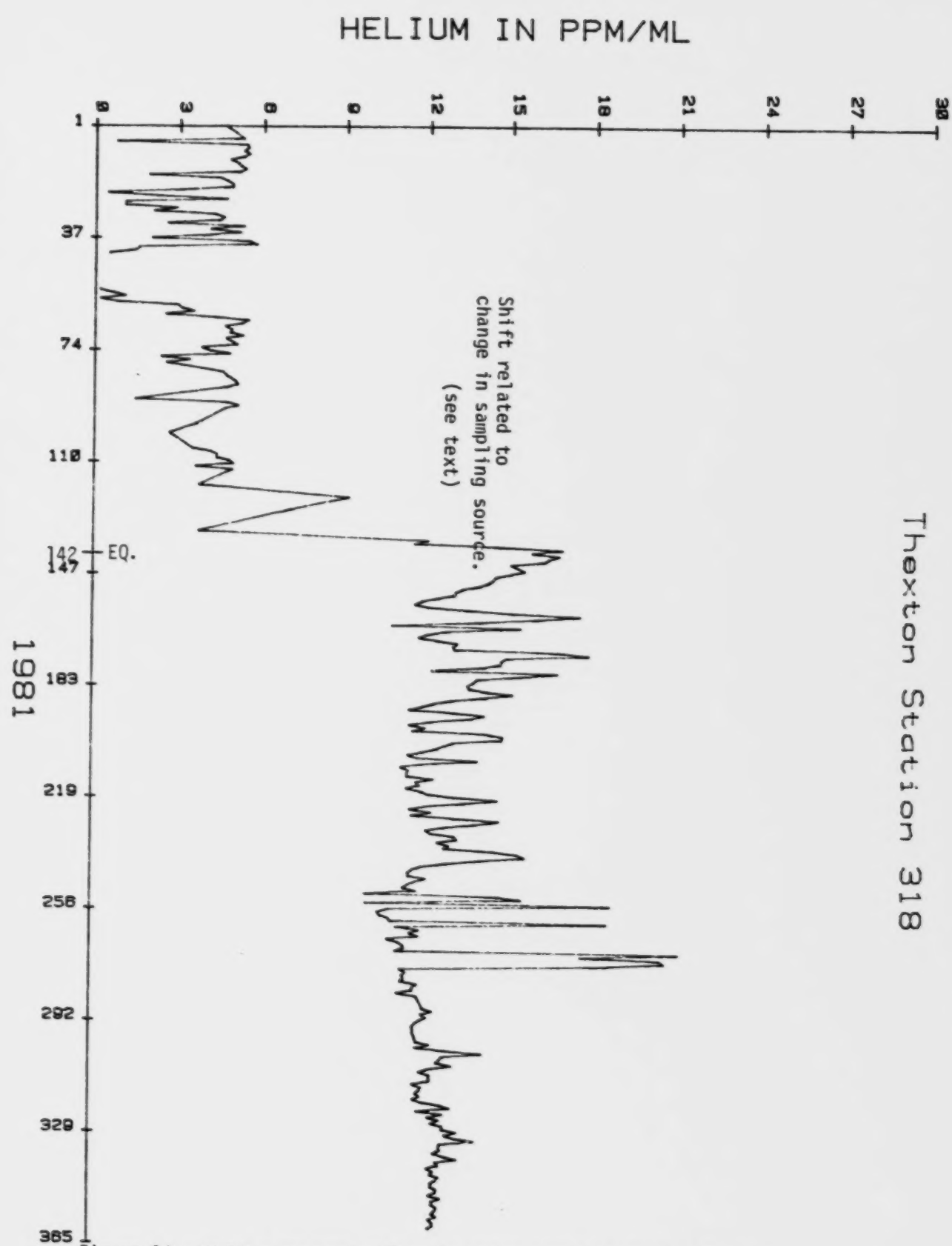

Figure 14.--Helium concentrations in water samples, Ennis, Montana.

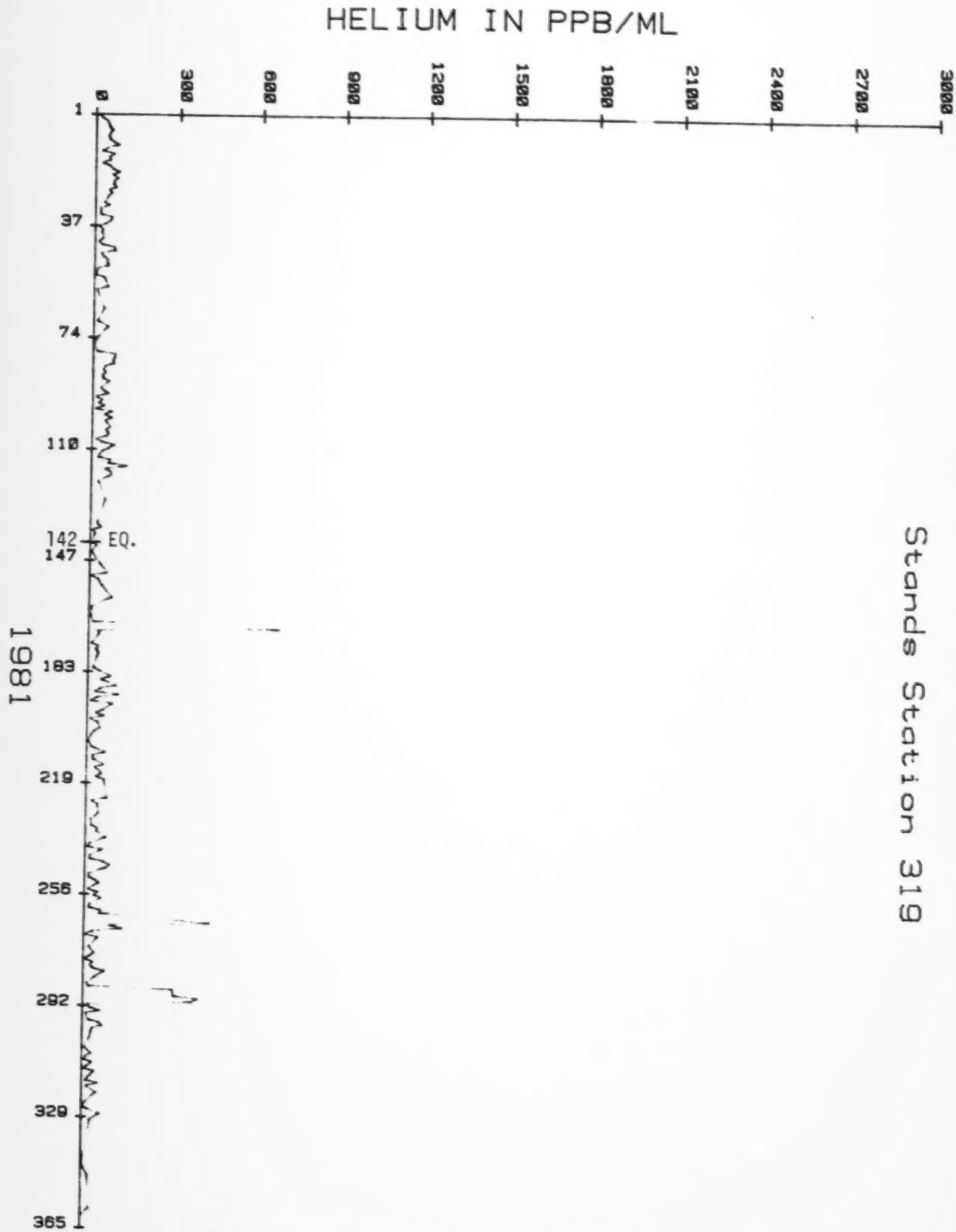

Figure 15.--Helium concentrations in water samples, Pray, Montana.

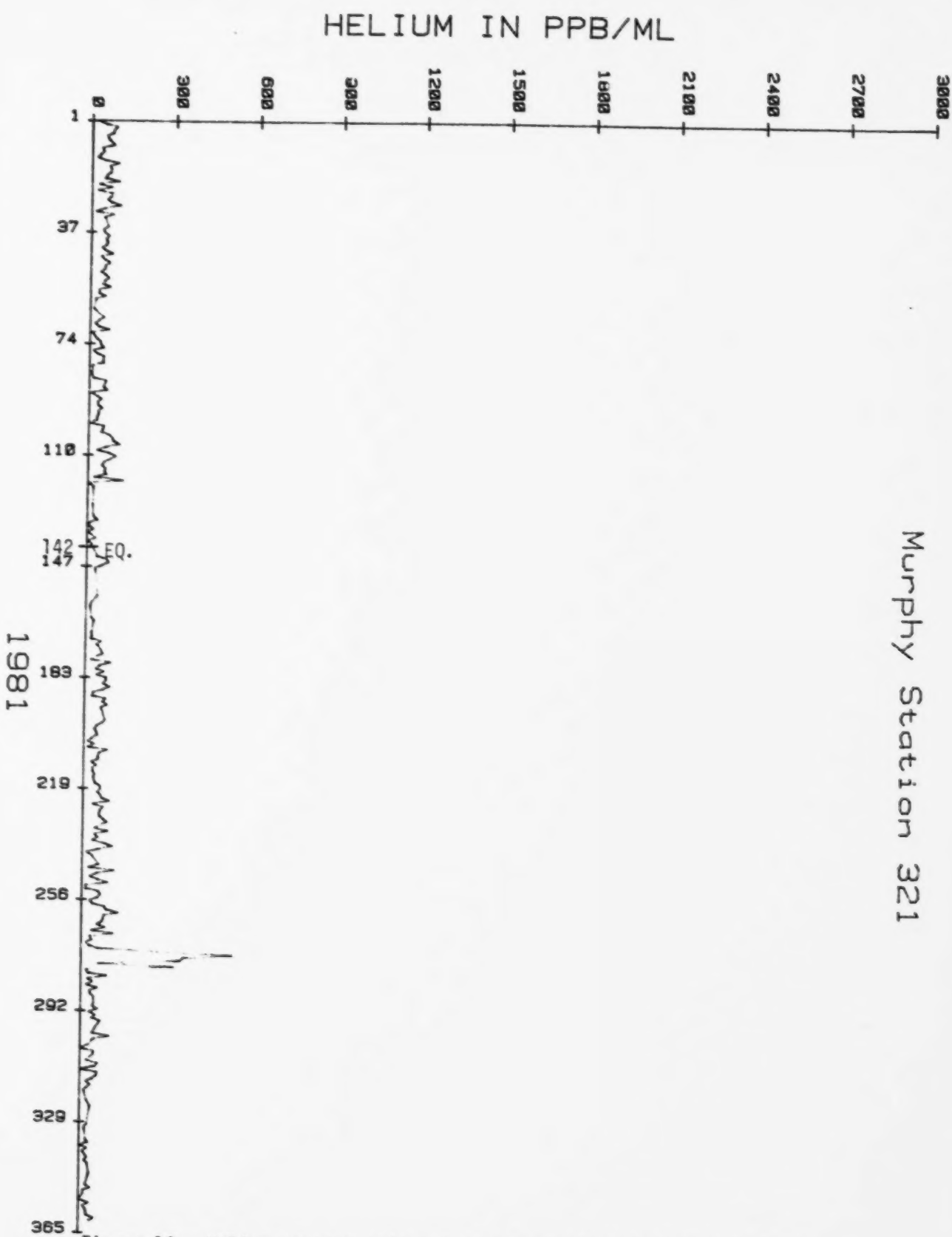

Figure 16.--Helium concentrations in water samples, Emigrant, Montana.

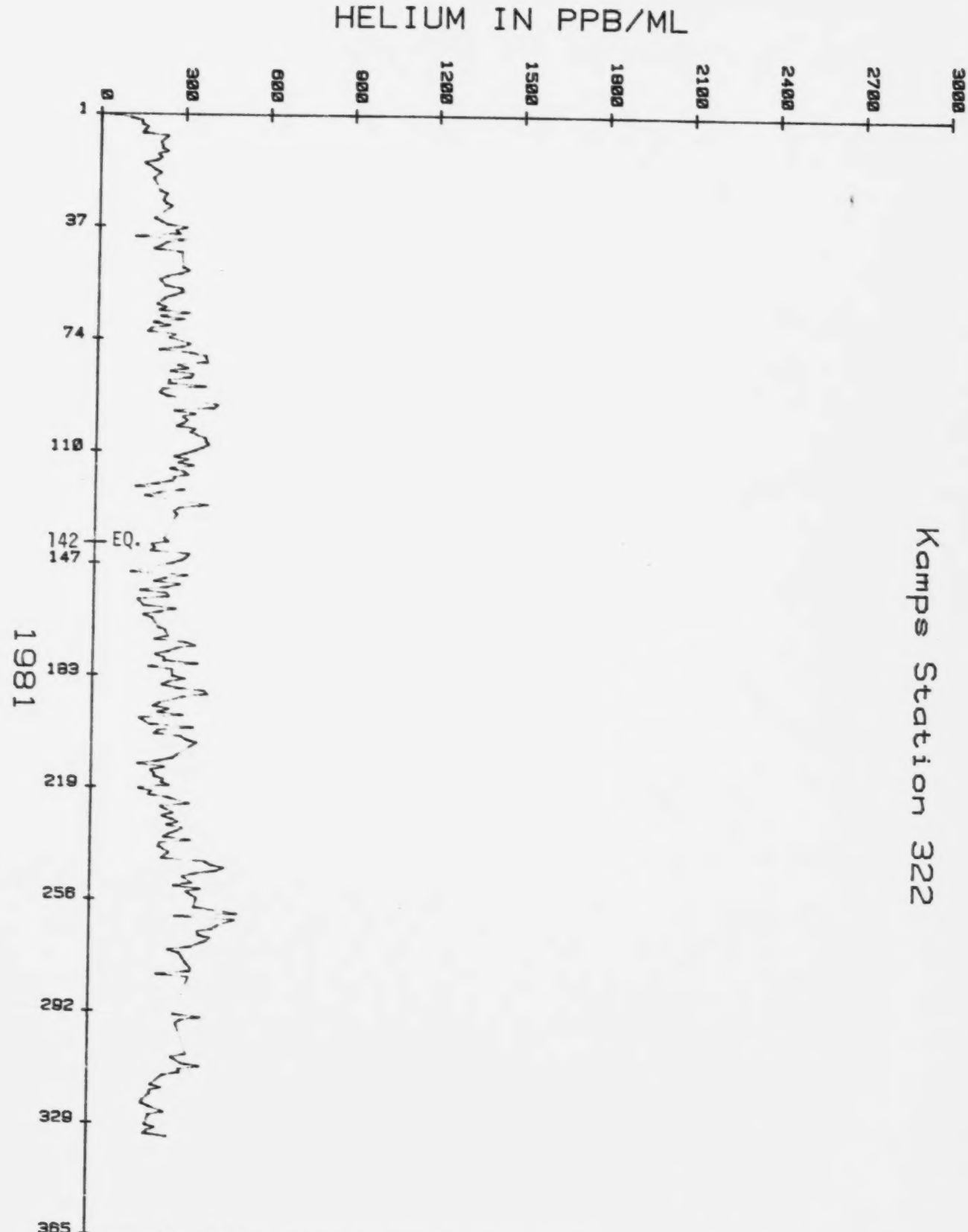

Figure 17.--Helium concentrations in water samples, Livingston, Montana.

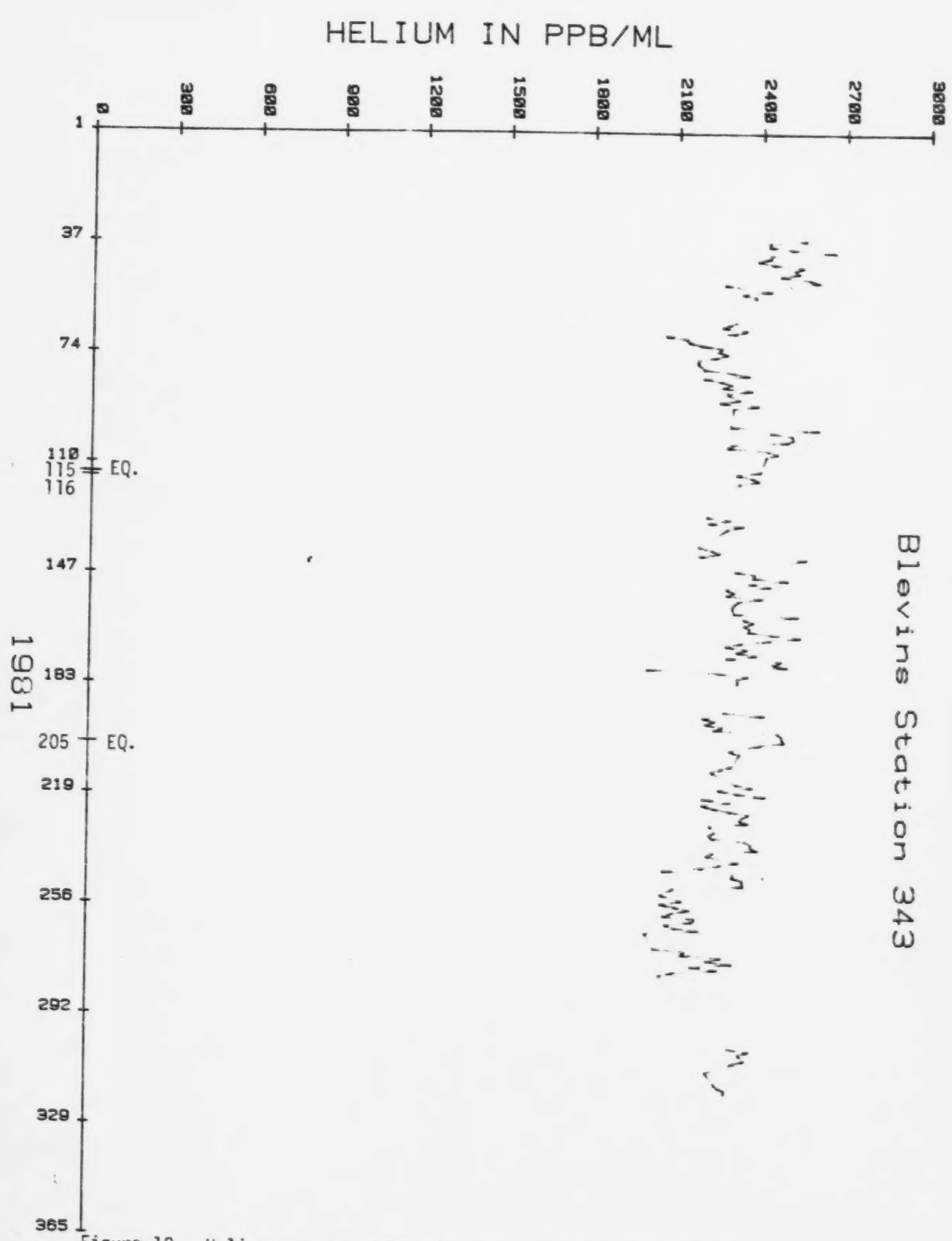

Figure 18.--Helium concentrations in water samples, Brawley, CA.

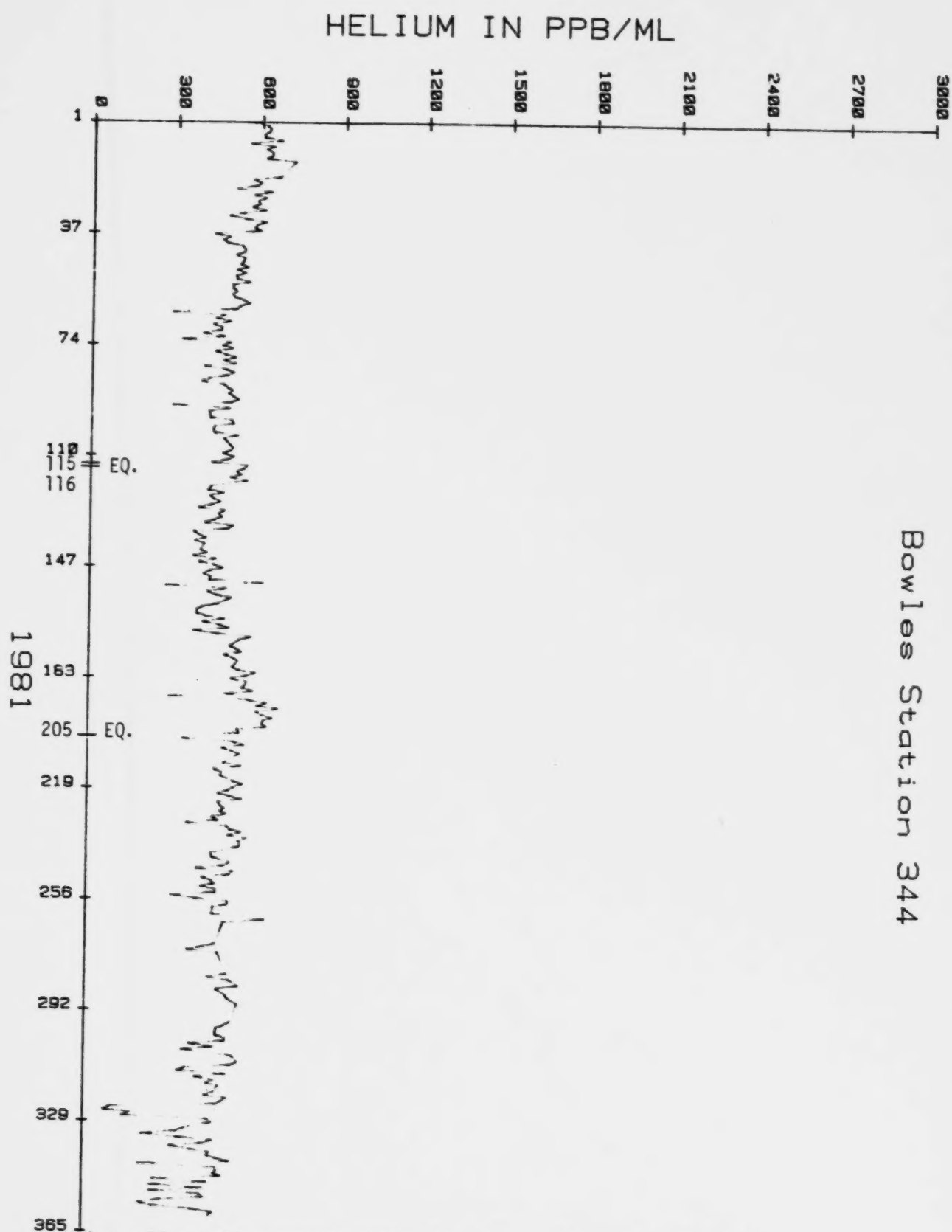

Figure 19.--Helium concentrations in water samples, Calipatria, CA.

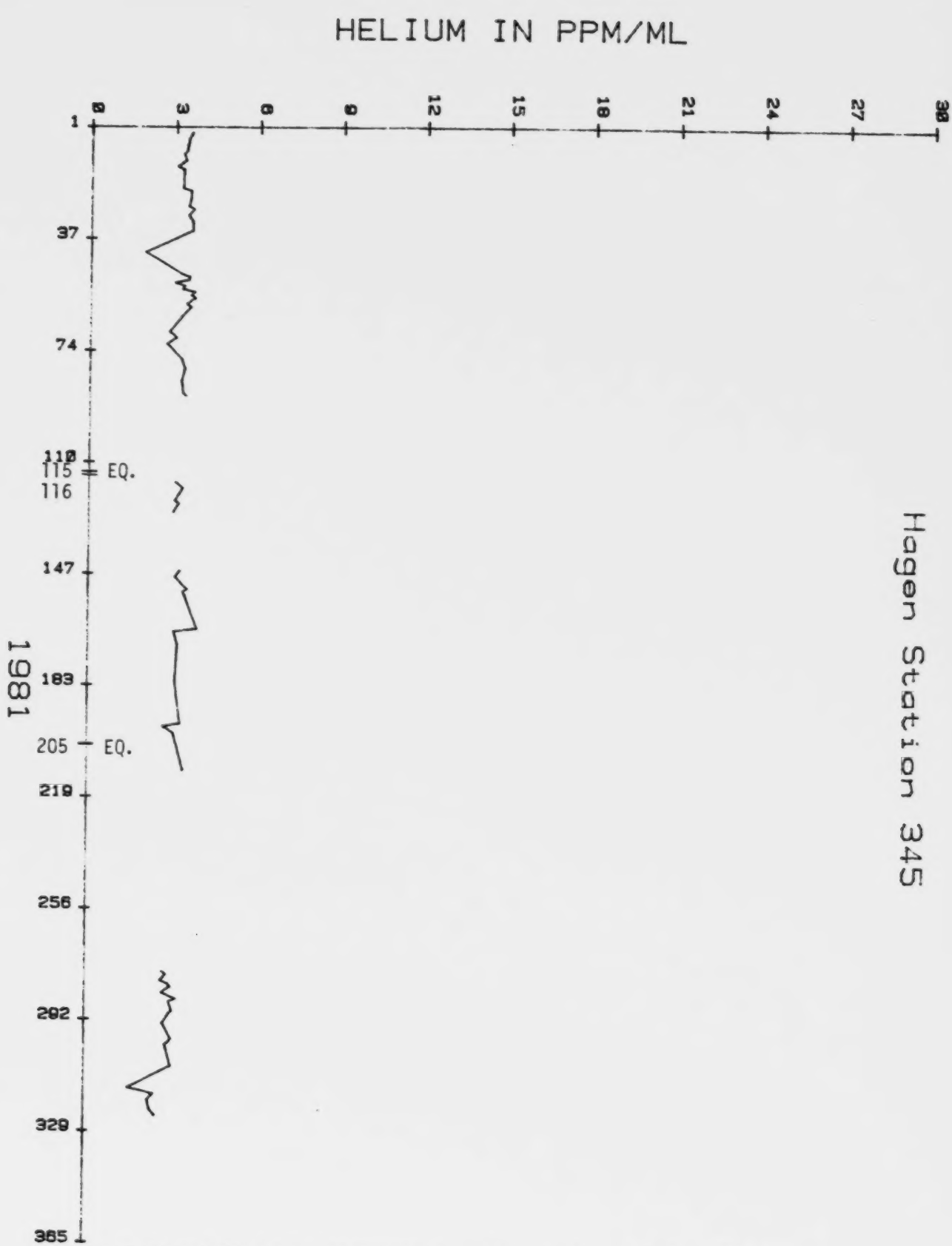

Figure 20.--Helium concentrations in water samples, Brawley, CA.

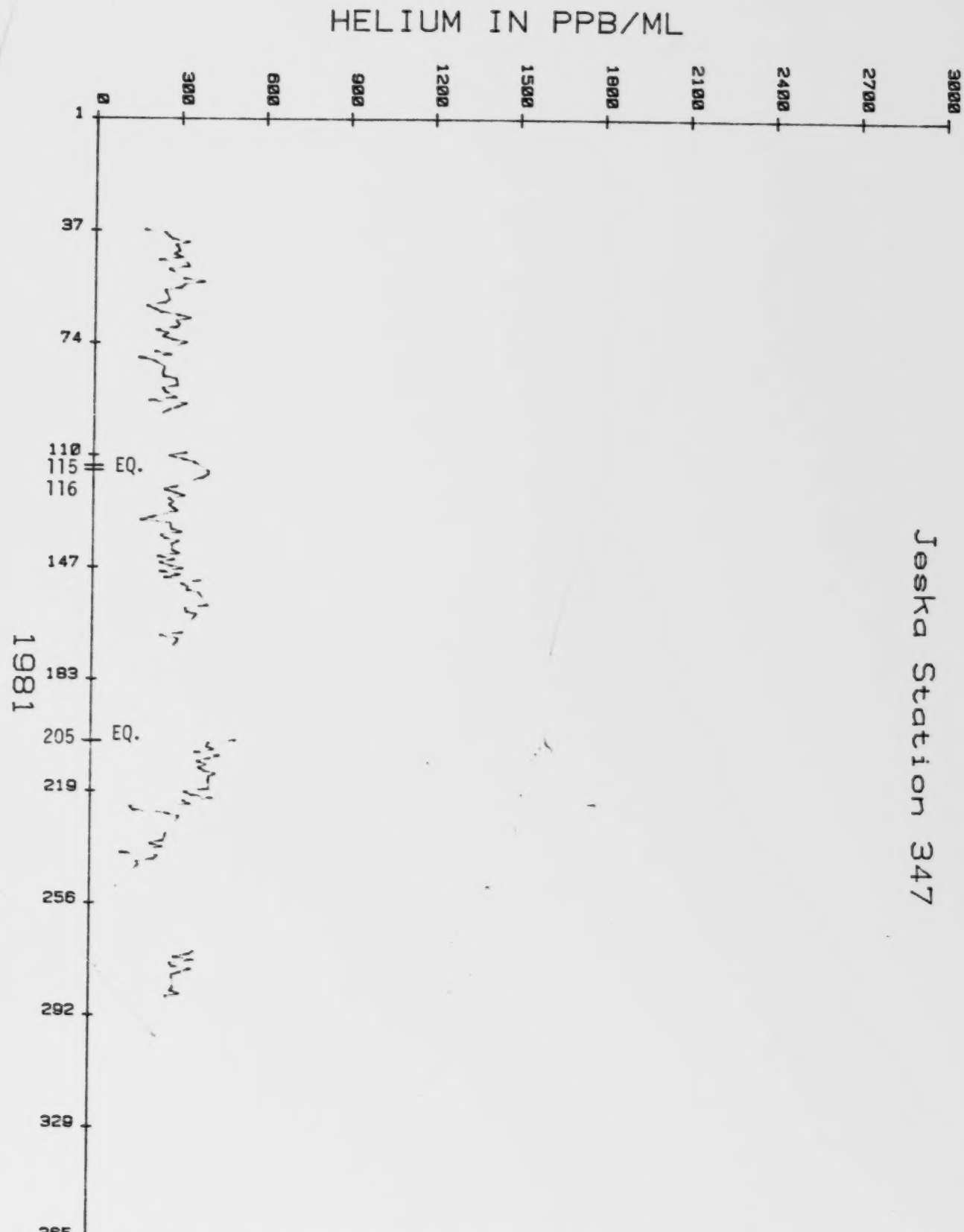

Figure 21.--Helium concentrations in water samples, Brawley, CA.

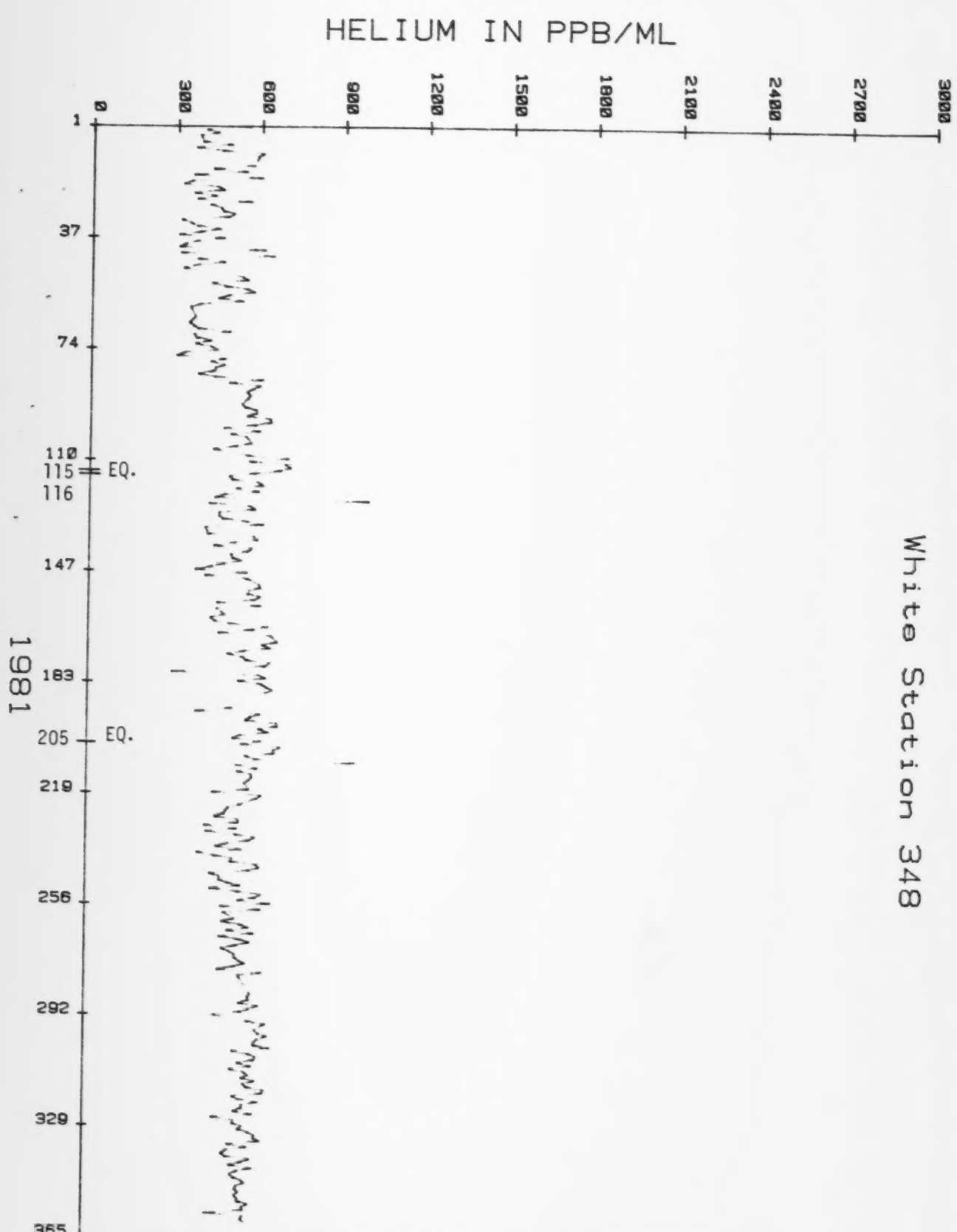

Figure 22.--Helium concentrations in water samples, Ocotillo, CA.

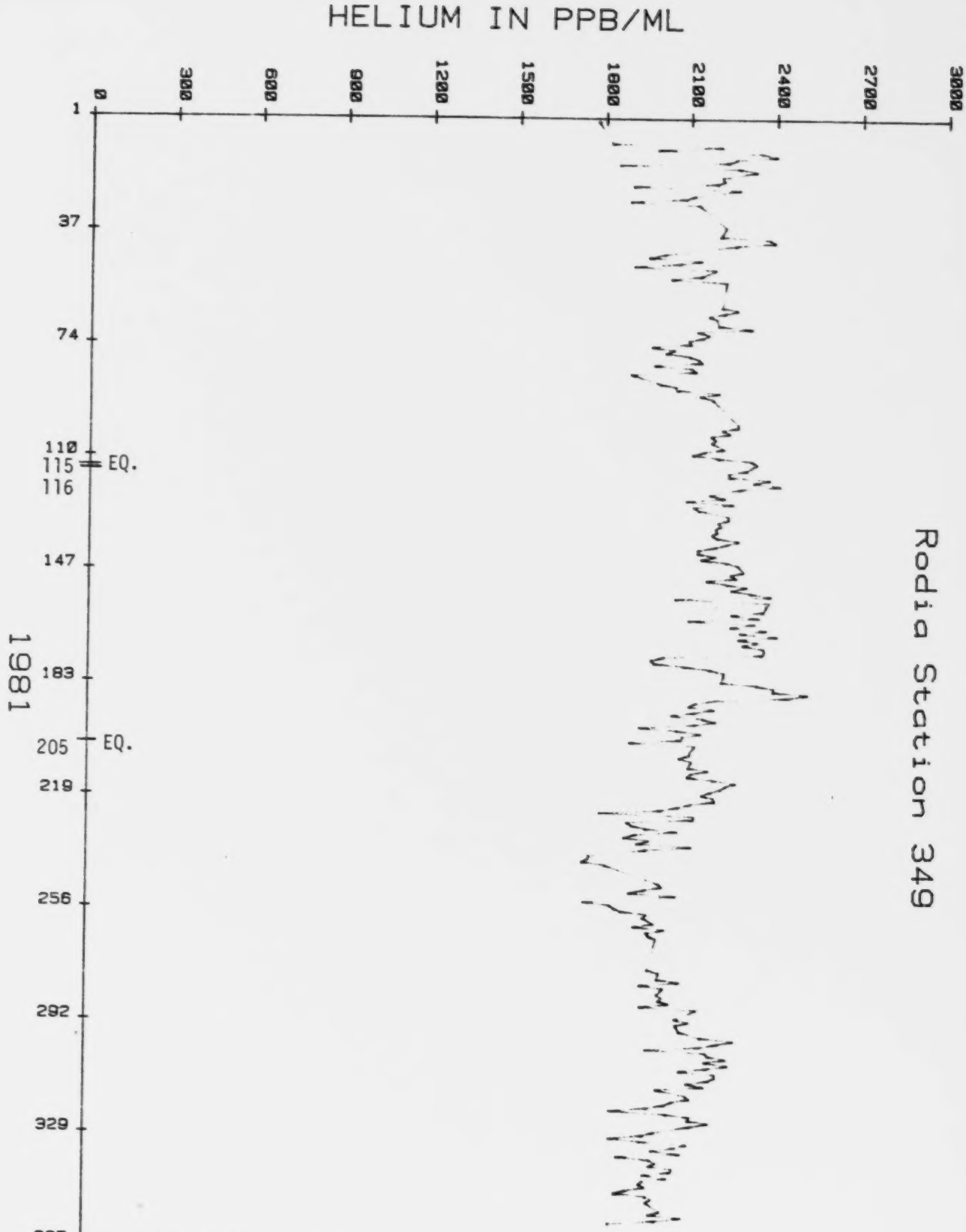

Figure 23.--Helium concentrations in water samples, Ocotillo, CA.

JULIAN DATE CALENDAR

(PERPETUAL)

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	060	091	121	152	182	213	244	274	305	335	1
2	002	033	061	092	122	153	183	214	245	275	306	336	2
3	003	034	062	093	123	154	184	215	246	276	307	337	3
4	004	035	063	094	124	155	185	216	247	277	308	338	4
5	005	036	064	095	125	156	186	217	248	278	309	339	5
6	006	037	065	096	126	157	187	218	249	279	310	340	6
7	007	038	066	097	127	158	188	219	250	280	311	341	7
8	008	039	067	098	128	159	189	220	251	281	312	342	8
9	009	040	068	099	129	160	190	221	252	282	313	343	9
10	010	041	069	100	130	161	191	222	253	283	314	344	10
11	011	042	070	101	131	162	192	223	254	284	315	345	11
12	012	043	071	102	132	163	193	224	255	285	316	346	12
13	013	044	072	103	133	164	194	225	256	286	317	347	13
14	014	045	073	104	134	165	195	226	257	287	318	348	14
15	015	046	074	105	135	166	196	227	258	288	319	349	15
16	016	047	075	106	136	167	197	228	259	289	320	350	16
17	017	048	076	107	137	168	198	229	260	290	321	351	17
18	018	049	077	108	138	169	199	230	261	291	322	352	18
19	019	050	078	109	139	170	200	231	262	292	323	353	19
20	020	051	079	110	140	171	201	232	263	293	324	354	20
21	021	052	080	111	141	172	202	233	264	294	325	355	21
22	022	053	081	112	142	173	203	234	265	295	326	356	22
23	023	054	082	113	143	174	204	235	266	296	327	357	23
24	024	055	083	114	144	175	205	236	267	297	328	358	24
25	025	056	084	115	145	176	206	237	268	298	329	359	25
26	026	057	085	116	146	177	207	238	269	299	330	360	26
27	027	058	086	117	147	178	208	239	270	300	331	361	27
28	028	059	087	118	148	179	209	240	271	301	332	362	28
29	029		088	119	149	180	210	241	272	302	333	363	29
30	030		089	120	150	181	211	242	273	303	334	364	30
31	031		090		151		212	243		304		365	31

FOR LEAP YEAR USE REVERSE SIDE

Figure 24.--Chart showing correlation of Julian and Gregorian calendar.